TORC

ROBOTIC BUILDING BLOCKS

SafeStop™ SS03 User Manual

Wireless Emergency Stop System

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Table of Contents

1 ASSIGNMENT OF LIABILITY 3

2 TECHNICAL SUPPORT 3

3 GENERAL SAFETY INFORMATION 4

4 PACKAGE CONTENTS 5
4.1 Included Items 5
4.2 Optional accessories 6

5 PRODUCT OVERVIEW 8

6 PRODUCT SPECIFICATIONS 10

7 SAFESTOP™ TRANSMITTER 11
7.1 Transmitter Switch Detail 12
7.2 Transmitter Power Receptacle 12
7.3 Transmitter LED Indicator Detail 14
7.4 Transmitter Audible Alarm 14

8 SAFESTOP™ RECEIVER 16
8.1 Receiver Bypass Button Detail 17
8.2 Receiver Power Receptacle Detail 18
8.3 Receiver Safety Receptacle Detail 19
8.4 Receiver Output Circuit Schematic 20
8.5 Receiver LED Indicator Detail 21

9 TCP (TELNET) COMMUNICATIONS 22
9.1 TELNET Testing 25

10 RS-232 SERIAL COMMUNICATIONS 28

11 WEB CONFIGURATION 29
11.1 System Status 29
11.2 System Configuration 30
11.3 External Watchdogs 32
11.4 Network Settings 33
11.5 Multipoint Transmitters 34

10.6 Firmware Updates 37

12 RESTORE NETWORK AND SYSTEM DEFAULTS 39

13 SYSTEM INTEGRATION 40
13.1 Charging the Transmitter Battery 40
13.2 Installing the Antennas 40
13.3 Installing the Receiver Cables into the Vehicle System 40
13.4 Example 5V Logic Level Wiring Schematics 41
13.5 Example Vehicle Wiring Schematics 41
13.6 Example External Button Wiring Schematics 42
13.7 Verify Operation of the System 42

14 PHYSICAL DIMENSIONS 45
14.1 SafeStop™ Transmitter Dimensions 45
14.2 Transmitter Mount Dimensions 46
14.3 SafeStop™ Receiver Dimensions 47
14.4 SafeStop™ Receiver Mounting Template 47

15 FCC COMPLIANCE 49

16 LIMITED WARRANTY 49

1 ASSIGNMENT OF LIABILITY

WARNING: DO NOT OPERATE UNTIL USER MANUAL IS REVIEWED AND UNDERSTOOD. PRODUCT USE IS SUBJECT TO STRICT TERMS AND CONDITIONS. SEE TERMS AND CONDITIONS DOCUMENT FOR ADDITIONAL USE RESTRICTIONS. OPERATING PRODUCT IN VIOLATION OF USER RESTRICTIONS COULD RESULT IN PRODUCT MALFUNCTION, PROPERTY DAMAGE, AND PERSONAL INJURY INCLUDING DEATH.

NOTICE: USER ASSUMES ALL RISKS ASSOCIATED WITH POSSESSION OR USE OF PRODUCT AND RELATED SYSTEMS. USER AGREES TO INDEMNIFY, DEFEND AND HOLD HARMLESS TORC TECHNOLOGIES, LLC ("TORC") FROM ANY DAMAGES ARISING OUT OF POSSESSION OR USE OF PRODUCT AND RELATED SYSTEMS. TORC IS NOT LIABLE FOR ANY DAMAGES OF ANY KIND.

NOTICE: SEE TERMS AND CONDITIONS FOR ALL TERMS APPLICABLE TO USE OF THE PRODUCT OR RELATED SOFTWARE.

2 TECHNICAL SUPPORT

For technical assistance and repairs, please use the following contact information:

Mailing Address	Email & Phone Support
TORC Product Support	support@torctech.com
2200 Kraft Dr, Ste 2050	www.torctech.com
Blacksburg, VA 24060	Phone: (540) 443-9262

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All information contained in this manual is believed to be accurate at the time of printing, however, TORC Technologies, LLC reserves the right to make modifications to the specifications and operation of this product without obligation to notify any person or entity of such revision.

3 GENERAL SAFETY INFORMATION

The following symbols are used throughout the user manual to indicate a particularly hazardous condition.

WARNING: Indicates a hazardous condition that could result in serious injury or loss of life if not performed properly.

CAUTION: Indicates a hazardous condition or procedure that could result in damage to this product, or loss related to equipment malfunction.

NOTE: A note indicates information that may not be applicable regarding system safety but needs to be known for best system performance.

Use Redundant Safety Measures

This product is not intended to be used as the only safety stop device. It is the user's responsibility to ensure that adequate and redundant safety measures are implemented.

Use Proper Supplied Accessories

To prevent damage to the product, use only the recommended accessories, including power adapters, antennas, and cables.

Observe All Connector Ratings

To avoid shock hazard and/or damage to the product, do not exceed any voltage, current, or environmental ratings on any of the connectors.

Do Not Charge Unattended

To avoid fire hazard and/or damage to the product, monitor the SafeStop™ transmitter when connected to an external power supply.

Do Not Operate With Suspected Failures

If you suspect there is damage to the product, contact TORC to have it inspected before further use.

Do Not Modify or Disassemble

To avoid shock hazard and/or damage to the product, do not attempt to open the case, make modifications, or repair the device. Opening, modifying or repairing this device will void any applicable warranty and could prevent the device from operating properly.

Do Not Operate in Explosive Atmosphere

To avoid a fire hazard, do not operate in an explosive atmosphere, such as in the presence of flammable liquids or gases.

Use Within Range

To prevent unreliable operation, do not use this product outside of its specified range. A range check should be performed before using the SafeStop™ system.

4 PACKAGE CONTENTS

4.1 Included Items

After unpacking the contents, please verify the contents of the package includes the following items:

	Qty	Part Number	Description
	1	SS03TX**	SafeStop™ Transmitter unit
	1	SS03RX**	SafeStop™ Receiver unit
	2	ANT**01	Flexible Antenna (900 MHz antenna shown)
	1	SS03ACC	AC Power Adapter / Charger for SafeStop™ Transmitter

	1	SS03SFT	60” Safety Cable for SafeStop™ Receiver
	1	SS03PWR	60” Power Cable for SafeStop™ Receiver
	2	SS03ETH	Ethernet Plugs for SafeStop™ Receiver
	2	SS03ECP	Ethernet Caps for SafeStop™ Receiver

** Designates the frequency band: 04= 400 MHz, 09= 900 MHz, 13= 1.3 GHz, 24= 2.4 GHz

4.2 Optional accessories

Accessory	Part Number	Function
External Emergency Stop Button	SS03A001	Allows the user to place an Emergency Stop button on the exterior of a vehicle. Magnetic base with hard mount points.
External Emergency Override Button	SS03A002	Allows the user to place an Emergency Override button on the exterior of a vehicle. Magnetic base with hard mount points.
Transmitter Car Charger	SS03A003	Provides the user the ability to conveniently charge the SafeStop™ transmitter from any standard 12V automobile outlet.

Transmitter Bind Plug	SS03A004	Allows the pairing of a transmitter unit to any receiver.
Serial Interface Cable	SS03A005	Allows the user to interface with the receiver using the legacy RS-232 interface.
	ANT**02	External high gain antenna with magnetic mount. (900 MHz antenna shown)

*Standard RAM mount accessories are available for a variety of transmitter mounting options.

5 PRODUCT OVERVIEW

The SafeStop™ is a multi-level wireless emergency stop system, consisting of the SS03TX transmitter and the SS03RX receiver. The SafeStop™ system provides the ability to safely command an unmanned or autonomous vehicle to pause or stop from a remote location up to 6 miles away. The compact and lightweight transmitter contains an internal rechargeable battery that enables continuous operation for up to 12 hours. Two hardware outputs are available for the user on the SS03RX receiver: an emergency stop output and an emergency override output. Each of these outputs can be overridden with hardwired external buttons, however only the emergency stop output is remotely controlled by the SS03TX transmitter. The status of all of the outputs and inputs can be read from a simple TCP interface through either of the two Ethernet ports on the receiver. An audible alarm and indicator lights provide user feedback of system state, link status, and battery life. System configuration and firmware updates are accessed using a web-based configuration interface. For manned operation, the wireless link may also be disabled using a bypass switch on the receiver.

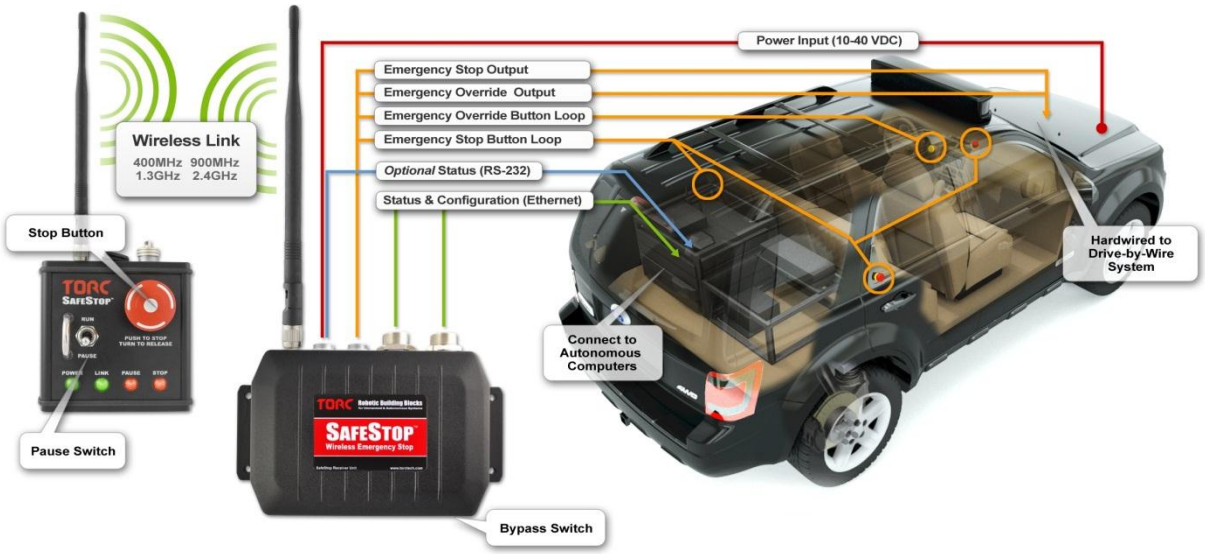


Figure 5-1: System Integration Example

The SafeStop™ has three safety modes: pause, emergency stop, and emergency override. Pause mode is intended to indicate a temporary pause in autonomous or unmanned vehicle operation and is considered to be a software only condition. There is no hardware output associated with the pause state. Emergency stop mode is intended to indicate a serious hardware or software condition that should cause the vehicle to be immediately disabled. The hardware emergency stop output is controlled by a red emergency stop button on the transmitter. Emergency

override mode is intended to be used to be a hardware only condition that entirely bypasses the SafeStop™ embedded software to disable the system.

The safety architecture of the SafeStop™ receiver implements the use of two independent processors that continuously monitor the system. In order for a vehicle to be placed in a running state both processors must be in agreement. If a discrepancy is detected, each processor has the ability to individually place the system in an emergency stop state. In addition, the code on the secondary processor on the receiver meets the Motor Industry Software Reliability Association Guidelines for the use of the C language in critical systems (MISRA-C:2004). The SafeStop™ receiver also includes redundant network ports and power inputs.

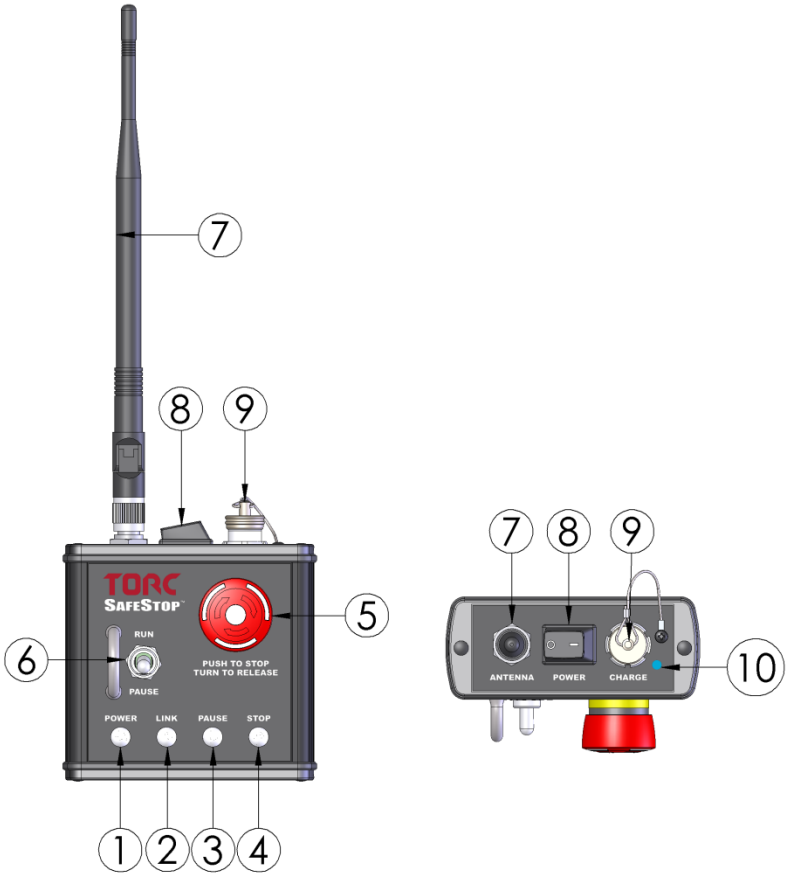
Multiple SS03 transmitters may be used to control a single SS03 SafeStop™ receiver. Configured through the webpage, a user may select up to 10 SafeStop™ transmitters to simultaneously control a single SafeStop™ receiver. The effective range of the SafeStop™ system can be increased by utilizing multiple transmitters.

6 PRODUCT SPECIFICATIONS

Performance	
Operating Distance with Single Transmitter:	6 miles* (line-of-sight)
Update Rate:	20 Hz
Wireless Link	
Frequency Band:	902-928MHz (Other frequencies available)
Transmit Power:	1W
Modulation:	FHSS GFSK
FCC Approved:	Yes
Transmitter Electrical	
SS03TX Battery Life:	12 hours*
SS03TX Input Voltage (charging):	12/24 VDC, +/- 10%
SS03TX Power Consumption:	15 W
Receiver Electrical	
SS03RX Input Voltage (V_{IN}):	10-40 VDC
SS03RX Power Consumption:	8 W
Vehicle Interface / Output Ratings	
Digital Communications:	TCP/IP over Ethernet (serial optionally available)
Emergency Stop Output Rating:	1.5A Continuous (sink or source)
Emergency Override Output Rating:	1.5A Continuous (sink or source)
Emergency Stop Output Min Voltage:	V_{IN} – 2.4V
Emergency Override Output Min Voltage:	V_{IN} – 2.4V
User Interface	
User Settings:	Web browser configuration interface
Stop Input:	Standard mushroom type stop button (50,000 Operations Minimum)
Pause Input:	Guarded toggle switch (50,000 Operations Minimum)
Bypass Mode:	Momentary pushbutton sequence
Visual Indicators:	Bicolor LEDs for Power, Link, Pause, and Stop
Audible Alarm :	Tone emitted for link lost and low battery
Environmental	
Dust / Water Resistance:	Receiver: IP67 Transmitter: IP64
Operational Temperature:	-20°C to 70°C
Operational Humidity:	10% to 90%, non-condensing
Operational Shock Rating:	15 g

*Performance data based on optimal conditions

7 SAFESTOP™ TRANSMITTER



ITEM	Description
1	Power Status Indicator
2	Link Status Indicator
3	Pause Status Indicator
4	Stop Output Indicator
5	Emergency Stop Button
6	Run/Pause Toggle Switch
7	Flexible Antenna (900 MHz antenna shown)
8	Power Switch
9	Charging Receptacle
10	Charge Status Indicator

Figure 7-1: SafeStop™ Transmitter Callouts

7.1 Transmitter Switch Detail

There are three switches located on the transmitter: the Power rocker switch, the Pause/Run toggle switch, and the Emergency Stop button.

When the Power rocker switch is in the "1" position, the transmitter is powered. With the switch in the "0" position, the transmitter is shut down and will no longer receive or transmit data.

The Pause/Run toggle switch is used to update the status message sent over TCP/IP or serial by the receiver. Flip the switch up to put the system in run mode, and down to put the system in pause mode. For details of this message, see section 9.

The Emergency Stop button is a push-to-stop/turn-to-release style mushroom button and controls the emergency stop output line on the receiver. When pushed, the emergency stop output is pulled to GND, and when released the emergency stop output is connected to V_{IN}.

7.2 Transmitter Power Receptacle

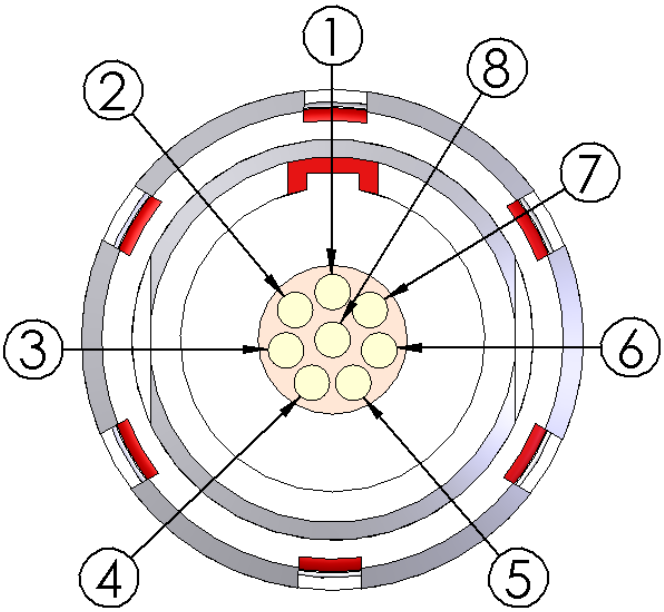
The transmitter Power Receptacle is used for charging the internal rechargeable battery and powering the transmitter from an external power source such as the transmitter car charger (P/N: SS03A003).

WARNING: Do not leave the SafeStop™ transmitter unattended while charging the battery.

WARNING: Only charge the battery using an approved power adapter

WARNING: Only charge the battery at room temperature.

WARNING: Replace the included connector end cap when finished charging the transmitter. The transmitter environmental ratings are only valid when mated to the charger or the end cap is installed.



Pin	Description
1	Power Input
2	Factory Use Only
3	Ground (GND)
4	Factory Use Only
5	Factory Use Only
6	Factory Use Only
7	Factory Use Only
8	Factory Use Only

Figure 7-2: Transmitter Power Receptacle Detail

7.3 Transmitter LED Indicator Detail

Indicator	Status	Meaning
Power	Off	Unit power is off
	Red	Less than 20% battery life remaining
	Green	Unit power is on
Link	Red	Communications link has been lost
	Green	Communications link is active
Pause	Off	Pause message state is unknown due to lost link
	Red	Receiver is in Pause mode
	Green	Receiver is in Run mode
Stop	Off	State of Stop output is unknown due to lost link
	Red	Stop output on receiver is pulled to GND
	Green	Stop output on receiver is connected to V_{in}
Charge Status	Off	Charger Disconnected / Error
	Orange	Charging
	Green	Charge Complete
	Red	Charge Error

Figure 7-3: Transmitter LED Detail

7.4 Transmitter Audible Alarm

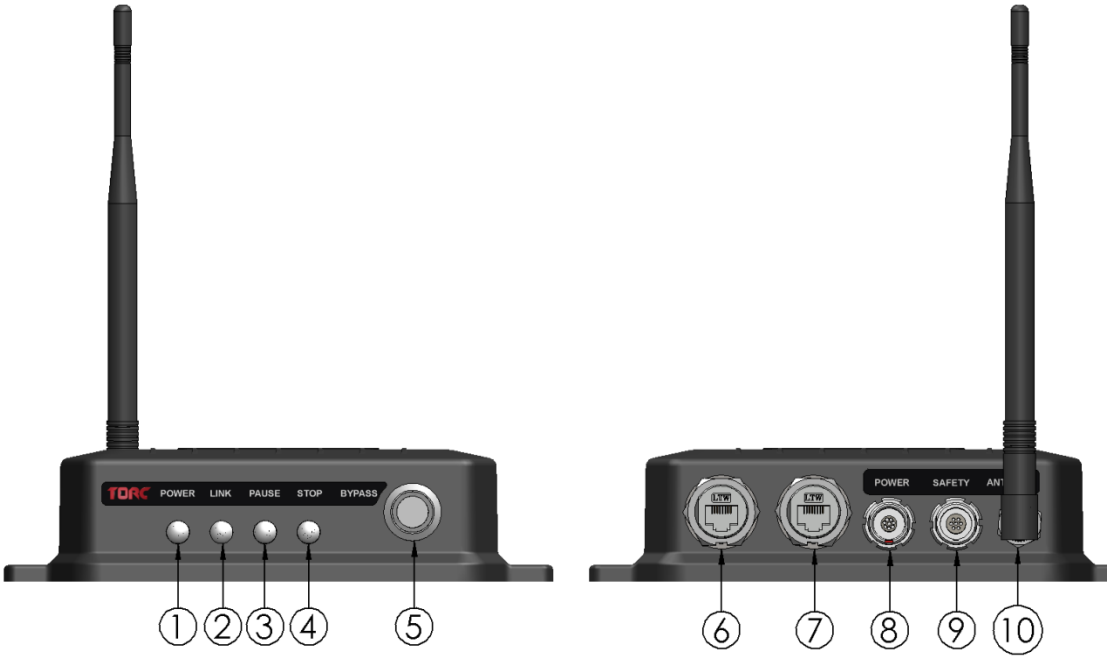
The SafeStop™ transmitter features an audible alarm to indicate an error condition that requires immediate user intervention. If the communication link is lost, the SafeStop™ transmitter is no longer in communication with the receiver, and the transmitter will emit a constant tone. The transmitter needs to be brought back within range of the receiver before operation can resume.

If the battery drops to approximately 20% of its total capacity, the audible alarm will start to sound 3 short tones every 5 seconds. If this occurs, power the transmitter off external power using either the supplied AC adapter (P/N: SS03ACC) or optional DC adapter (P/N: SS03DCA) to charge the battery. The low battery audible alarm will turn off shortly after the transmitter is powered off external power.

Alarm	Meaning
Continuous	Communication link with receiver has been lost
Three Short Tones	Less than 20% battery life remaining

Figure 7-4: Transmitter Audible Alarm Detail

8 SAFESTOP™ RECEIVER



ITEM	Description
1	Power Status Indicator
2	Link Status Indicator
3	Pause State Indicator
4	Stop Output Indicator
5	Bypass Pushbutton
6	RJ-45 Ethernet Jack
7	RJ-45 Ethernet Jack
8	Power Receptacle
9	Safety Receptacle
10	Antenna Connector

Figure 8-1: SafeStop™ Receiver Callouts

8.1 Receiver Bypass Button Detail

The SafeStop™ receiver features an illuminated pushbutton used to enable Bypass Mode. Bypass mode causes the receiver to ignore wireless transmitter commands and link loss conditions, and therefore should only be used during manned operation. The emergency stop and emergency override external inputs are still active and can cause a stop or override condition through the use of wired external buttons. When in bypass mode, the bypass button will be illuminated blue, the Pause indicator will be green, and the stop indicator will reflect the status of the external emergency stop button loop. Even though the receiver ignores wireless commands from all transmitters while in bypass mode, the link LED will reflect actual link status. If the link LED is green prior to exiting bypass mode, the receiver will immediately transition to the state of the connected transmitter upon exiting.

WARNING: While in Bypass Mode, the receiver will not accept Stop or Pause commands from the transmitter.

NOTE: Turning on power to a transmitter linked to a receiver placed in bypass mode will cause the transmitter to act as if the link is lost, sounding the audible alarm.

ENTER BYPASS MODE

To enable Bypass Mode the user must follow a deliberate procedure designed to prevent accidental entry into Bypass Mode by untrained personnel. This procedure is outlined below.

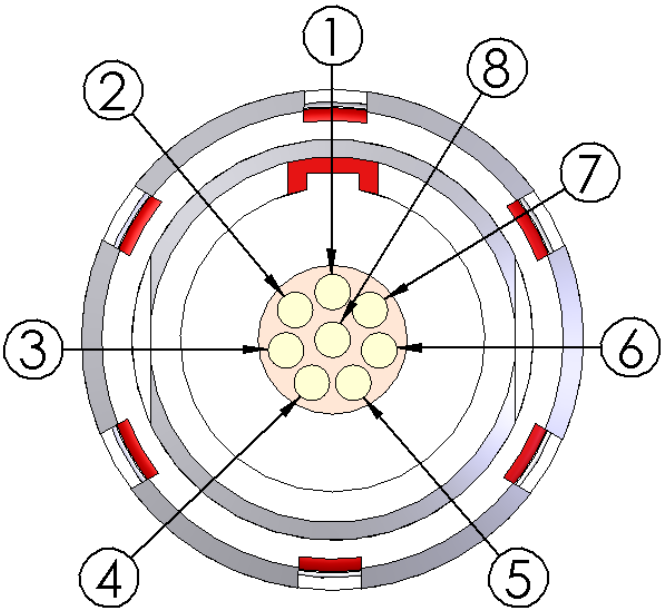
1. Press the Bypass button. The blue ring will illuminate after a random delay between 0.2 and 2 seconds.
2. While the blue ring is illuminated press the Bypass button again. This will turn off the blue ring for another random delay between 0.2 and 2 seconds.
3. While the blue ring is illuminated, press the Bypass button a third time
4. If the Bypass procedure was completed successfully the blue ring will remain illuminated.
5. If, however, at any point the Bypass procedure was unsuccessful the blue ring will begin to flash. At this point the user must wait for the flashing to stop and begin the process again.

EXIT BYPASS MODE

To exit bypass mode press and release the bypass button. Once released the blue illumination ring will turn off and the receiver will wait up the user defined timeout delay for a wireless link to the transmitter before executing the timeout action. It is possible to prevent the SafeStop™ receiver from executing the timeout action when exiting bypass by ensuring that there is an active link with a transmitter. The link LED only on the receiver illuminates green when an active link is detected in bypass mode. If no link is detected the link LED will illuminate red. The transmitter link LED will always illuminate red when the receiver is placed in bypass mode.

8.2 Receiver Power Receptacle Detail

The Power receptacle is used to supply power to the receiver. Whichever input voltage is higher will be used for the emergency stop / override outputs. This connector is also used for serial RS-232 output.

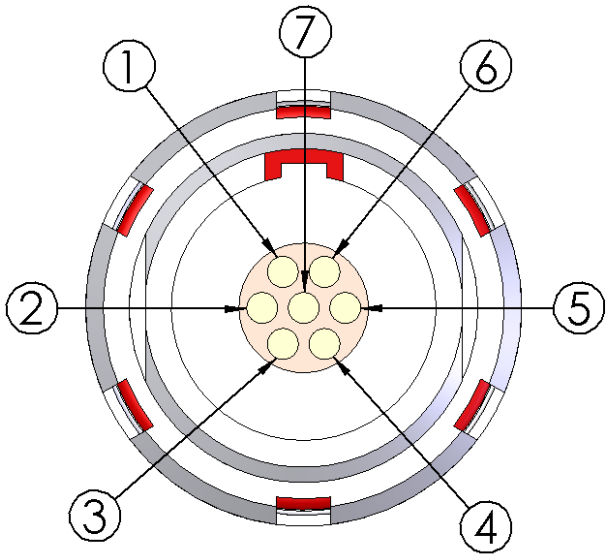


ITEM	Description	Power Cable Wire Color (SS03PWR)
1	Power Input A	Red
2	Power Input B	White
3	Ground (GND)	Black
4	Serial TX	
5	Serial RX	
6	Factory Use Only	
7	Factory Use Only	
8	Ground (GND)	Green

Figure 8-2: Receiver Power Receptacle Detail

8.3 Receiver Safety Receptacle Detail

The Safety receptacle is used for the Emergency Override and Emergency Stop connections. Loop A and Loop B should be connected together for normal operation. Breaking the current loop (disconnecting Loop A and Loop B) will cause the corresponding output to be connected to GND. When an Emergency Stop or Emergency Override has not been triggered, the corresponding output will be connected to the input voltage. When the system is powered off both outputs are pulled down to GND.



ITEM	Description	Safety Cable Wire Color (SS03SFT)
1	Emergency Stop Output	Red
2	Emergency Override Output	Orange
3	Emergency Stop Loop A	Green
4	Emergency Override Loop A	Blue
5	Emergency Stop Loop B	White
6	Emergency Override Loop B	Brown
7	Ground (same as power GND)	Black

Figure 8-3: Receiver Safety Receptacle Detail

8.4 Receiver Output Circuit Schematic

There are two independent processors within the receiver that have control over the Emergency Stop Output. Each processor verifies correct operation of the system and will deactivate the emergency stop output if an error is detected. While each processor can individually ground the Emergency Stop Output, both processors must be in agreement for the Emergency Stop Output to be driven to the input voltage V_{IN}. When driven high, both the Emergency Stop and Emergency Override Outputs will be driven to V_{IN} through several diode drops, resulting in a minimum output voltage of $V_{IN} - 1.6V_{DC}$.

In addition, the Emergency Stop Output is controlled by any external buttons that may be connected to the Emergency Stop Loop A and Loop B pins. If the Emergency Stop Loop A and Loop B pins are left unconnected, the Emergency Stop Output will always be driven low regardless of the commands from the SafeStop™ transmitter. The button loops for both Emergency Stop and Override outputs are current loops that do not require any external power sources. When Loop A and Loop B pins are connected together, an internal current source will supply approximately 15mA through the loop.

CAUTION: The Emergency Stop and Emergency Override button loops have internal current supplies and do not require external power.

To ensure the Emergency Output Line is pulled low when power is disconnected from the SafeStop™ receiver, an internal pull-down resistor of 2.49kΩ is connected to the Emergency Stop Output and Emergency Override lines. The Emergency Stop Output is also fused internally.

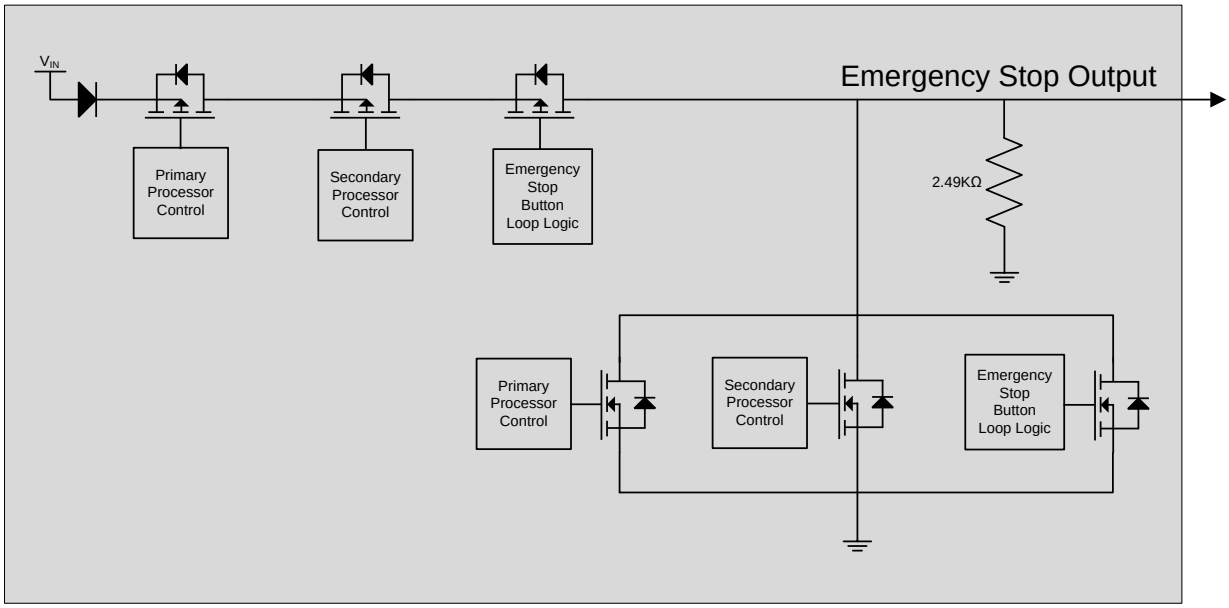


Figure 8-4: Emergency Stop Output Schematic

Unlike the Emergency Stop Output, the Emergency Override Output is not software controlled by the processors. The Emergency Override Output is only controlled through the Emergency

Override button loop. When **Emergency Override Loop A** (Safety connector pin4) and **Emergency Override Loop B** (Safety connector pin 6) are connected the Emergency Override Output is driven high to V_{IN}, otherwise the output is driven to GND. When power is disconnected a pull down of 2.49kΩ will pull the outputs to ground.

8.5 Receiver LED Indicator Detail

Indicator	Status	Meaning
Power	Off	Unit power is off
	Red	System Error
	Green	Unit is powered on
Link	Red	Communications link all transmitters has been lost
	Green	Communications link to a transmitter is active
Pause	Red	Receiver Status state is Pause
	Green	Receiver Status state is Run
Stop	Red	Stop output is tied to GND
	Green	Stop output is tied to V_{IN}
Bypass	Off	Normal Operation
	Blue	Bypass Mode activated
	Blinking	Bypass Entry Procedure

Figure 8-5: Receiver LED Indicator Detail

9 TCP (TELNET) COMMUNICATIONS

The SafeStop™ accepts TCP ASCII commands. All commands are one word commands followed by a carriage return (0x0D) character and new line (0x0A) character. Only NVT(Network Virtual Terminal) ASCII characters are valid, and any telnet option requests will trigger a WONT or DONT response (See RFC 854 for details). This permits the use of either a standard telnet client (such as Putty) or a raw TCP connection to port 23.

STOP – returns the state of the wired emergency stop output
Usage: **STOP<0x0D><0x0A>**

Command: **STOP<0x0D><0x0A>**	
Possible Response	Meaning
STOP NONE<0x0D><0x0A>	The emergency stop button loop is closed, there are no other stop conditions, and the emergency stop output is tied to V_{IN}
STOP WIRELESS<0x0D><0x0A>	The receiver has received a transmitter stop command, the emergency stop output is tied to GND
STOP WIRELESS WIRED<0x0D><0x0A>	The emergency stop button loop is open and the transmitter is sending an emergency stop command, the emergency stop output is tied to GND
STOP TIMEOUT<0x0D><0x0A>	There is no link between the receiver and transmitter, the user configured timeout action will be executed, the emergency stop output is tied to GND
STOP TIMEOUT WIRED<0x0D><0x0A>	The emergency stop button loop is open and there is no link between the receiver and transmitter, the emergency stop output is tied to GND
STOP WIRED<0x0D><0x0A>	The emergency stop button loop is open, the emergency stop output is tied to GND
STOP WATCHDOG<0x0D><0x0A>	The external watchdog timer has expired, the user configured timeout action will be executed, the emergency stop output is tied to GND
STOP WIRELESS WATCHDOG<0x0D><0x0A>	The receiver has received a transmitter stop command, the external watchdog timer has expired, the emergency stop output is tied to GND
STOP WIRELESS WIRED WATCHDOG<0x0D><0x0A>	The emergency stop button loop is open and the transmitter is sending an emergency stop command, the external watchdog timer has expired, the emergency stop output is tied to GND
STOP TIMEOUT WATCHDOG<0x0D><0x0A>	There is no link between the receiver and transmitter, the external watchdog timer has expired, the user

	configured timeout action will be executed, the emergency stop output is tied to GND
STOP TIMEOUT WIRED WATCHDOG<0x0D><0x0A>	The emergency stop button loop is open and there is no link between the receiver and transmitter, the external watchdog timer has expired, the emergency stop output is tied to GND
STOP WIRED WATCHDOG<0x0D><0x0A>	The emergency stop button loop is open, the external watchdog timer has expired, the emergency stop output is tied to GND
STOP LATCHED<0x0D><0x0A>	Latching stop is enabled, a stop even has occurred but has been cleared, and the system requires a wired stop to clear the stop status, the emergency stop output is tied to GND
STOP TRANSITION<0x0D><0x0A>	The secondary processor has cleared the stop but the message from secondary to primary has not yet been processed, the emergency stop output is tied to GND. NOTE: This state should only be seen temporarily between other states.

OVERRIDE – returns the state of the wired emergency override output
Usage: **OVERRIDE<0x0D><0x0A>**

Command: **OVERRIDE<0x0D><0x0A>**	
Possible Response	Meaning
OVERRIDE WIRED<0x0D><0x0A>	The emergency override button loop is open, the override output is tied to GND
OVERRIDE NONE<0x0D><0x0A>	The emergency override button loop is closed, the emergency override output is tied to V_{IN}

PAUSE – returns the state of the PAUSE toggle switch on the transmitter. Without any hardware pause outputs on the receiver, the only way to detect the state of the pause switch is in software through the pause command.
Usage: **PAUSE<0x0D><0x0A>**

Command: **PAUSE<0x0D><0x0A>**	
Possible Response	Meaning
PAUSE TIMEOUT<0x0D><0x0A>	There is no link between the receiver and a transmitter
PAUSE WIRELESS<0x0D><0x0A>	The receiver has received a transmitter pause command

PAUSE WATCHDOG<0x0D><0x0A>	The external watchdog has expired
PAUSE TIMEOUT WATCHDOG<0x0D><0x0A>	There is no link between the receiver and any transmitter, and the external watchdog has expired
PAUSE WIRELESS WATCHDOG<0x0D><0x0A>	The receiver has received a transmitter pause command and the external watchdog has expired
PAUSE NONE<0x0D><0x0A>	The Run/Pause toggle switch on the transmitter has been placed in the Run position

LINK – returns the status of the wireless link between the SafeStop™ receiver and transmitter
Usage: **LINK<0x0D><0x0A>**

Command: **LINK<0x0D><0x0A>**	
Possible Response	Meaning
LINK BYPASS<0x0D><0x0A>	Receiver has been placed into bypass
LINK 0%<0x0D><0x0A>	No wireless link detected
LINK XX%<0x0D><0x0A>	Wireless link active, signal strength at XX%

TXSTATUS – returns the status of all transmitters currently in control of the receiver
Usage: **TXSTATUS<0x0D><0x0A>**

Command: **TXSTATUS<0x0D><0x0A>**	
Possible Response	Meaning
TXID NONE<0x0D><0x0A>	No active transmitter links
TXID VVVV: Status=0xWW Link=XX% Batt=YY% FW=ZZ	Transmitter ID “VVVV” stats displayed, repeated for each transmitter with an active link, “WW” indicates transmitter status code, “XX” indicates transmitter signal strength, “YY” indicates transmitter battery level, and ZZ indicates transmitter firmware revision

WATCHDOG – returns the status of the external watchdog
Usage: **WATCHDOG<0x0D><0x0A>**

Command: **WATCHDOG<0x0D><0x0A>**	
Possible Response	Meaning

WATCHDOG DISABLED<0x0D><0x0A>	External watchdog is disabled (set to 0)
WATCHDOG RUNNING(xx ms) <0x0D><0x0A>	External watchdog is enabled and running with a time limit of xx milliseconds.
WATCHDOG EXPIRED(xx ms) <0x0D><0x0A>	External watchdog is enabled and expired with a time limit of xx milliseconds.

FEED – does not return a response. Resets the countdown timer on the external watchdog. When the external watchdog is enabled, this message must be sent periodically to prevent the external watchdog from expiring.
Usage: **FEED<0x0D><0x0A>**

INFO – returns the SafeStop™ system firmware revision information
Usage: **INFO<0x0D><0x0A>**

VERSION – returns the SafeStop™ TCP communications protocol version
Usage: **VERSION<0x0D><0x0A>**

HELP – returns a list of supported commands
Usage: **HELP<0x0D><0x0A>**

To avoid having to query a message multiple times, some messages may be set up to periodically transmit at rates from 0 to 20 Hz. This is accomplished by appending the '@' character followed by an ASCII integer from 0-20. The commands that generate periodic messages are: STOP, OVERRIDE, PAUSE, LINK, and TXSTATUS. For example:

LINK@20<0x0D><0x0A> - periodically transmit the link status at a rate of 20Hz
STOP@1<0x0D><0x0A> - transmit the state of the wired emergency stop contact once a second
PAUSE@0<0x0D><0x0A> - disable periodic transmission of the pause command

9.1 TELNET Testing

To test the telnet interface on the SafeStop™, a standard telnet client such as PuTTY may be downloaded from the internet. In order to communicate with the SafeStop™ receiver, make sure to configure the connecting computer to be on the same network as the SafeStop™. For example, changing your computer's IP address to a static address of 192.168.0.100 will allow you to communicate with the SafeStop™ receiver when set to use the default IP address of **192.168.0.160**. To configure the PuTTY telnet client for testing the SafeStop™ advanced communication protocol, follow the steps outlined below.

In the "Session" menu, enter the IP address of the SafeStop™ and select the "Telnet" connection type (will auto-fill Port 23). These settings can be saved for future use by clicking the "Save" button. Once configured, click the "Open" button to create a TCP connection to the SafeStop™.

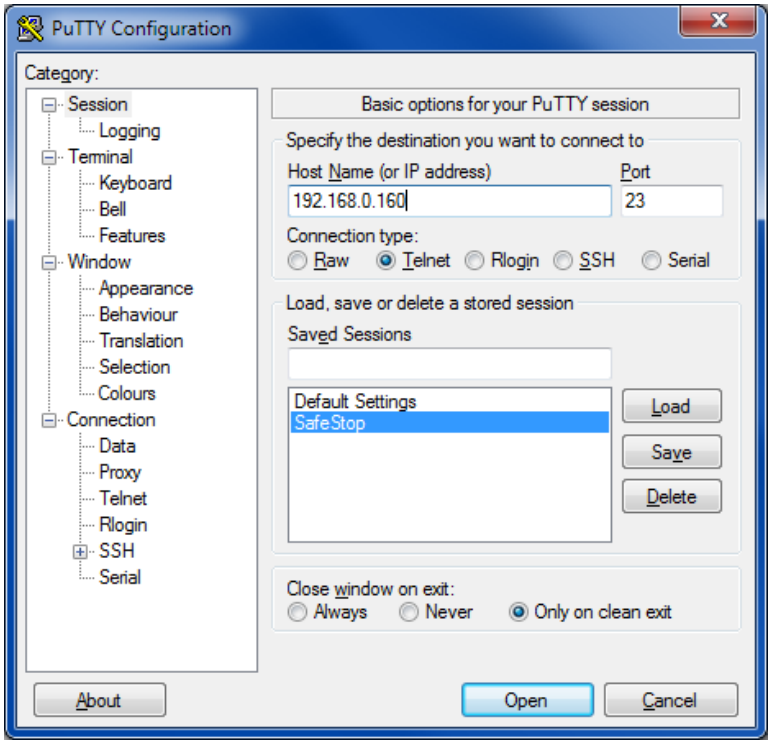


Figure 9-1: PuTTy Configuration

Once a session has been opened commands can be sent to the SafeStop™ receiver. In the figure below, the stop, pause, override, and link commands were sent to the receiver and the outputs can be seen.

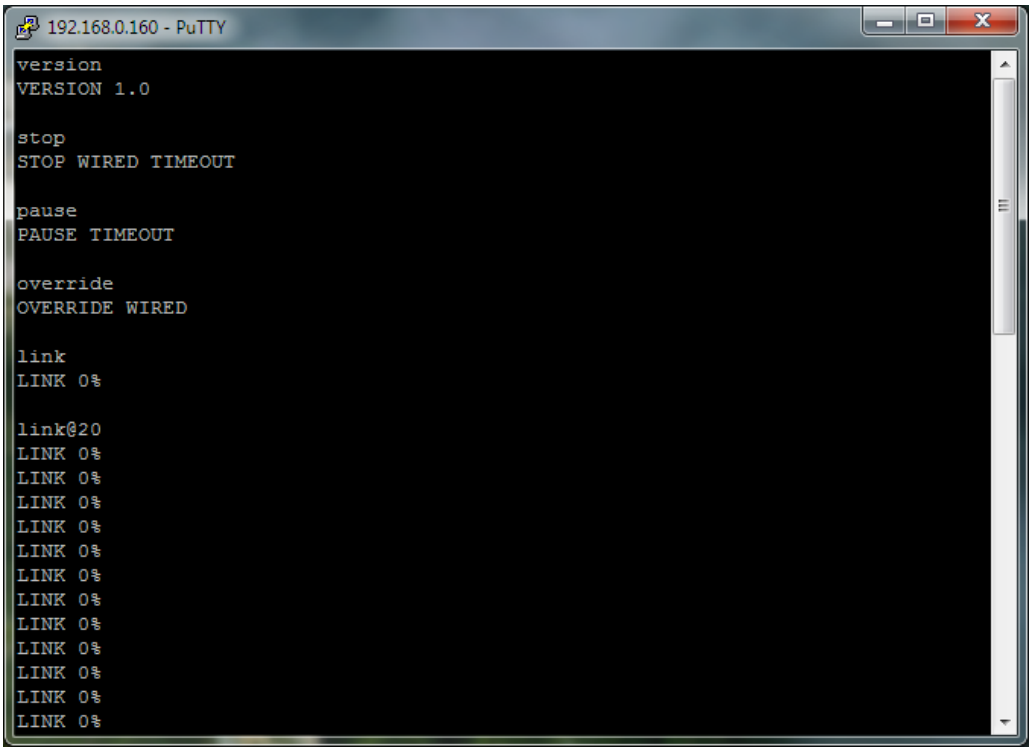


Figure 9-2: Example PuTTy Output

10 RS-232 SERIAL COMMUNICATIONS

Information about the Emergency Stop Output, the pause state, and the link state is sent serially over RS-232 communications. The data bit format is set to communicate at 9600bps, 8 data bits, 1 stop bit, no parity, and no flow control.

The serial protocol consists of 3 data bytes followed by a carriage return and line feed for a total of 5 bytes updated at a frequency of 20 Hz in the following format:

<Link Status><Run/Pause Status><Release/Stop Status><CR><LF>

Byte	Value	Description
<Link Status>	X	Link Lost
	B	Bypass Mode
	L	Link Active
<Run/Pause Status>	R	Run
	P	Pause
<Release/Stop Status>	R	Release
	S	Stop

After the initial diagnostic outputs, the standard serial output protocol will be continuously displayed.

11 WEB CONFIGURATION

The SafeStop™ receiver has a built in web server that allows the user to configure the system through a standard web browser. The default IP address for the SafeStop™ is **192.168.0.160**.

11.1 System Status

The System Status webpage allows for the monitoring of the current state of the SafeStop™ system. The first table shows the overall status of the system: receiver input voltage, receiver internal temperature, as well as the current run states: link, pause, stop, bypass, emergency override, timeout, and external watchdog status.

The second table contains a list of currently paired transmitters if any, and the state of each. It lists each paired transmitter by numerical ID, shows the pause, stop, and timeout status of the transmitter, as well as the radio link quality between the transmitter and the receiver, the current transmitter battery level, and current transmitter firmware version.

NOTE: The system status page refreshes every five seconds, so the webpage display may not reflect the most recent state of the system.

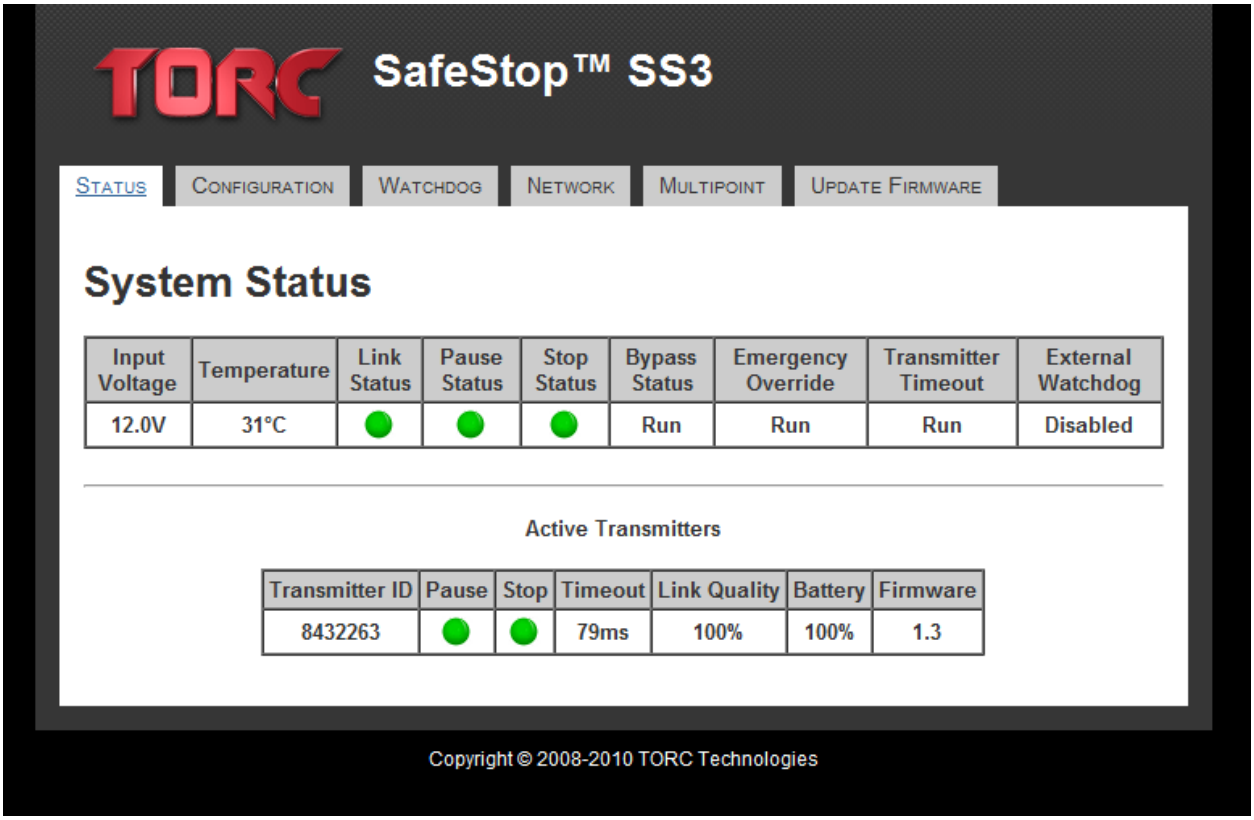


Figure 11-1: Status Webpage

11.2 System Configuration

The System Configuration webpage allows for the configuration of the system timeout delay, timeout action, latching stop action, radio modem power, radio modem frequency key, and the serial port baud rate.

The Timeout Delay is the amount of time the SafeStop™ receiver or transmitter will wait before deciding if wireless communications are lost. When wireless communications are lost, the link LED on both the transmitter and receiver will be red and the receiver will perform the user selected Timeout Action. The Timeout Delay can be set from 200 to 5000 milliseconds in 25 millisecond increments.

There are two Timeout Actions that the SafeStop™ receiver can perform upon a loss of communication between the receiver and transmitter. By default the Timeout Action is set to "Pause & Stop" where the receiver will return a **PAUSE TIMEOUT** in response to the **PAUSE** command in addition to pulling the Emergency Stop output contact to GND. If the Timeout Action is set to "Pause Only" then the state of the Emergency Stop Output will not change on a loss of communications. The only action taken on a loss of communications when the Timeout Action is set to "Pause Only" is the software response of **PAUSE TIMEOUT**.

System configuration also allows for selection between latching and non-latching operation. Latching mode can be selected with the "Latch On Stop" setting. When "Latch On Stop" is disabled, simply clearing all stop signals will exit a stopped state. When "Latch On Stop" is enabled, the only way to exit a stopped state is to make sure all stop signals are cleared, and to then press and release the wired stop button. Note that when enabled, the SafeStop™ system will always power up in a stopped state, and the wired stop button must be pressed and released.

In some instances it may be necessary to disable all wireless transmissions by the receiver. This can be accomplished by setting the "Radio Modem Power" to OFF, which will turn off power to the radio modem the next time the receiver is turned on. Turning the "Radio Modem Power" OFF will disable wireless communications between the SafeStop™ receiver and transmitter. In order to resume normal operation of the SafeStop™ system, "Radio Modem Power" must be set to ON and the receiver must cycle power.

The radio modems in the SafeStop™ system use spread spectrum frequency hopping technology. The frequency hopping pattern for the receiver can be selected by changing the "Frequency Key" setting. This should be done if multiple receivers are used in the same local area, as using different frequency keys for each receiver will lessen the likelihood of interference.

NOTE: The transmitter frequency key is set to match the receiver during the pairing process, so if the receiver frequency key is changed, all transmitters must be re-paired.

Saving settings on the system configuration webpage will not take effect immediately. Even though the new settings will be displayed on the webpage, the settings are only applied after power to the SafeStop™ receiver is reset.

Figure 11-2: Configuration Webpage

11.3 External Watchdogs

The SafeStop™ can be configured with an external watchdog timer that will trigger a pause and stop event if not refreshed, of fed, periodically. The settings for the external watchdog can be viewed or changed via the Watchdog tab. The timeout limit can be set in 10ms increments, with a maximum of 655,350ms. A setting of "0" disables the external watchdog. When enabled, the external watchdog will cause both PAUSE and STOP events after the timeout period expires. An external system must provide the reset of "FEED" command before timeout expiration by opening a telnet connection to the receiver and sending the message "FEED" followed by a carriage return. This message must be sent periodically within the time limit to keep the watchdog from expiring.

NOTE: Setting the external watchdog timeout below 250ms may cause intermittent operation due to the nature of TCP communications.

Figure 11-3: External Watchdog Webpage

11.4 Network Settings

The SafeStop™ can be configured to be accessed as a part of any network by changing the configurations on the Network Settings tab. A network settings change does not require power cycling, and will take effect immediately upon saving settings. The factory defaults are:

- IP Address: **192.168.0.160**
- Subnet Mask: **255.255.0.0**
- Gateway: disabled (**0.0.0.0**)

If network settings of the receiver are not known, factory defaults can be restored by following the procedure outlined in section 12.

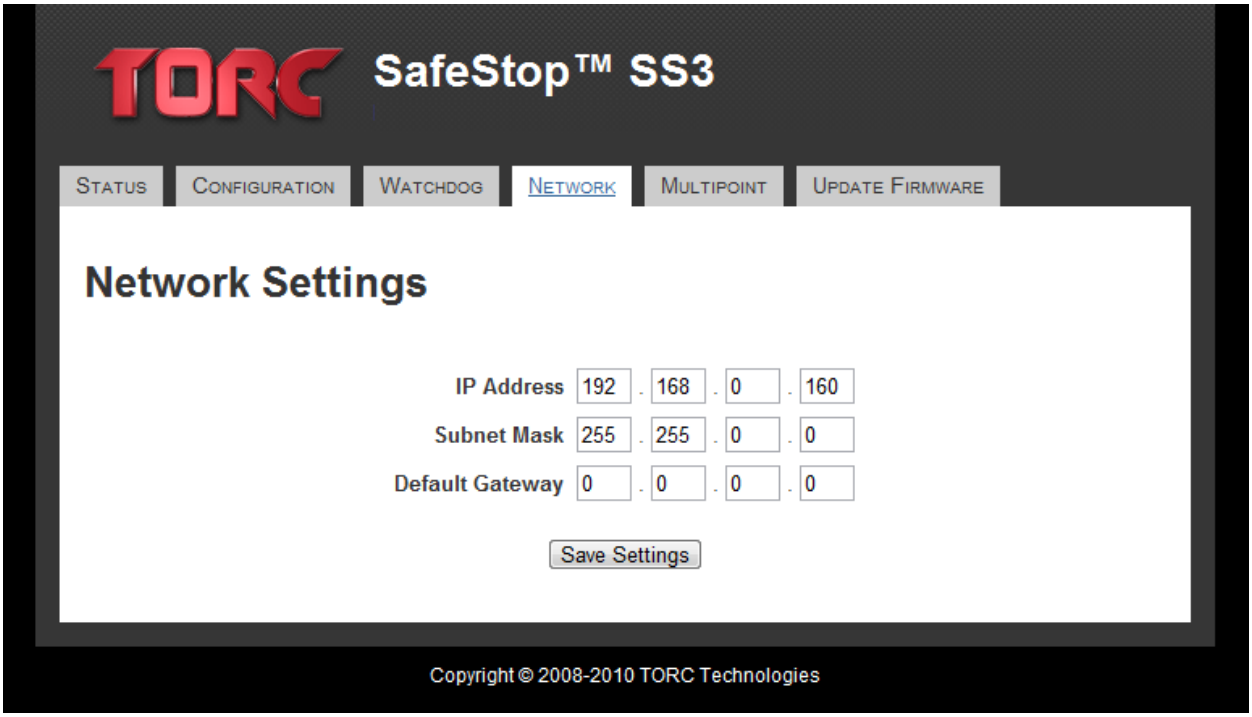


Figure 11-4: Network Settings Webpage

11.5 Multipoint Transmitters

The SafeStop™ system features the ability to allow the use of multiple transmitters to control a single receiver. The list of currently paired transmitters can be displayed on the Multipoint tab.

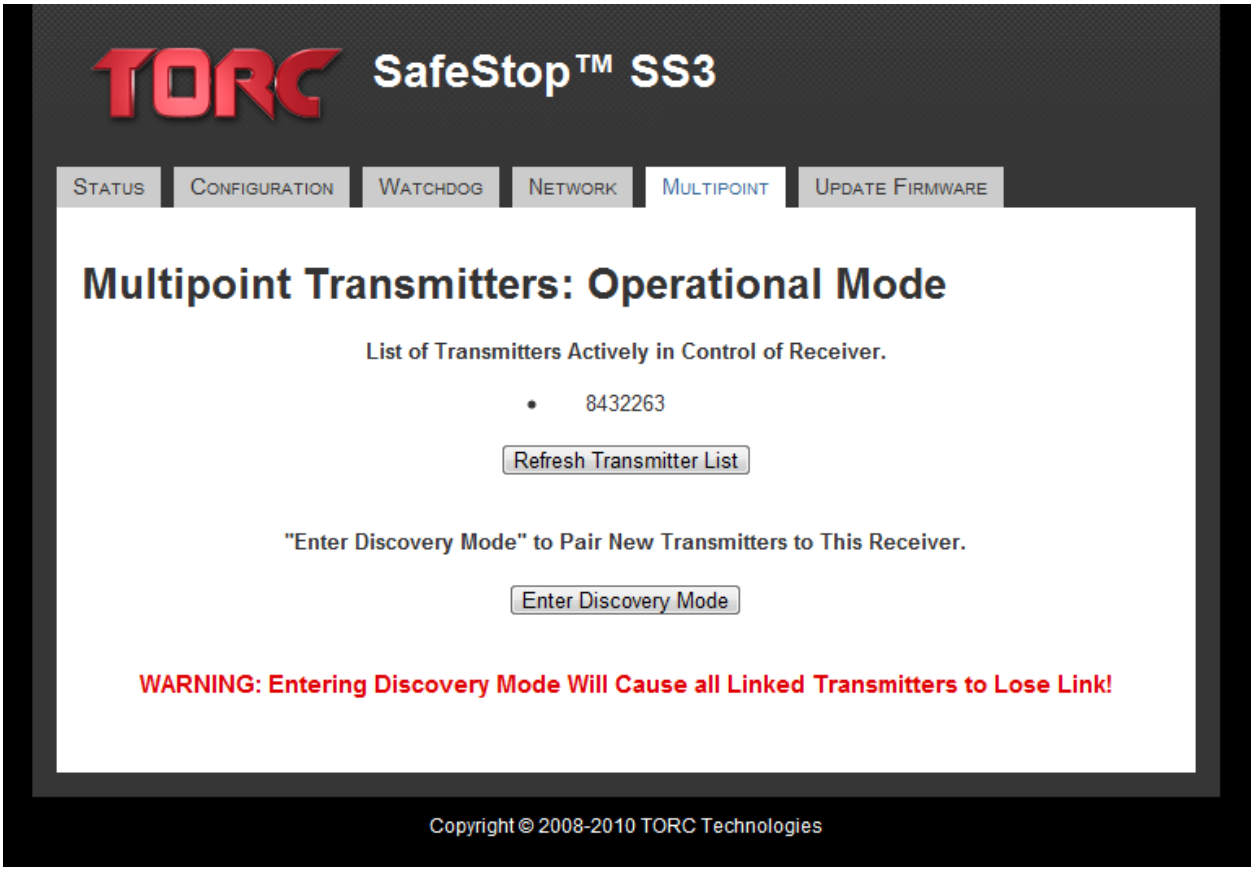


Figure 11-5: Multipoint Webpage

To pair a transmitter with a receiver, follow the steps outlined below.

1. Plug the included bind plug into the charging socket of the transmitter, then turn the transmitter power on. After a few moments, the POWER LED will turn green, and the LINK LED will flash green to indicate the transmitter is in pairing mode. Remove the bind plug.
2. Open a web browser and enter the receiver's IP address into the address field of the web browser. The default address is **192.168.0.160**
3. Under the multipoint tab, select the "Enter Discovery Mode" button to place the Receiver in discovery mode. The receiver POWER LED will stay green, the PAUSE and STOP LEDs will turn red, and the LINK LED will turn green when it detects a transmitter in discovery mode.

NOTE: When a receiver is placed in discovery mode, any transmitters already paired and linked with the receiver will lose link status until discovery mode is exited.

4. Select the "Refresh Transmitter List" button if the transmitter in pairing mode is not already displayed in the list.

5. Select the radio button next to the transmitter to be paired. The transmitter ID can be found on the transmitter manufacturing label.
6. Select the "Add Selected Transmitter" button.
7. The web page will display "Pairing in Progress" and then "Pairing Complete". The PAUSE and STOP LEDs on the transmitter will turn red, indicating successful pairing. Cycle power to the transmitter to exit pairing mode on the transmitter.
8. Select the "Pair Another Transmitter" button and repeat from step 1 to add an additional transmitter.
9. To exit discovery mode on the receiver, select the "Exit Discovery Mode" to return the receiver to normal operation.

NOTE: When multiple transmitters are paired with a receiver, the receiver will maintain an active STOP or PAUSE state of any transmitters that lose link status (turned off or go out of range). To clear a STOP or PAUSE caused by link loss, an active transmitter or wired stop must explicitly indicate STOP/PAUSE and then resume.

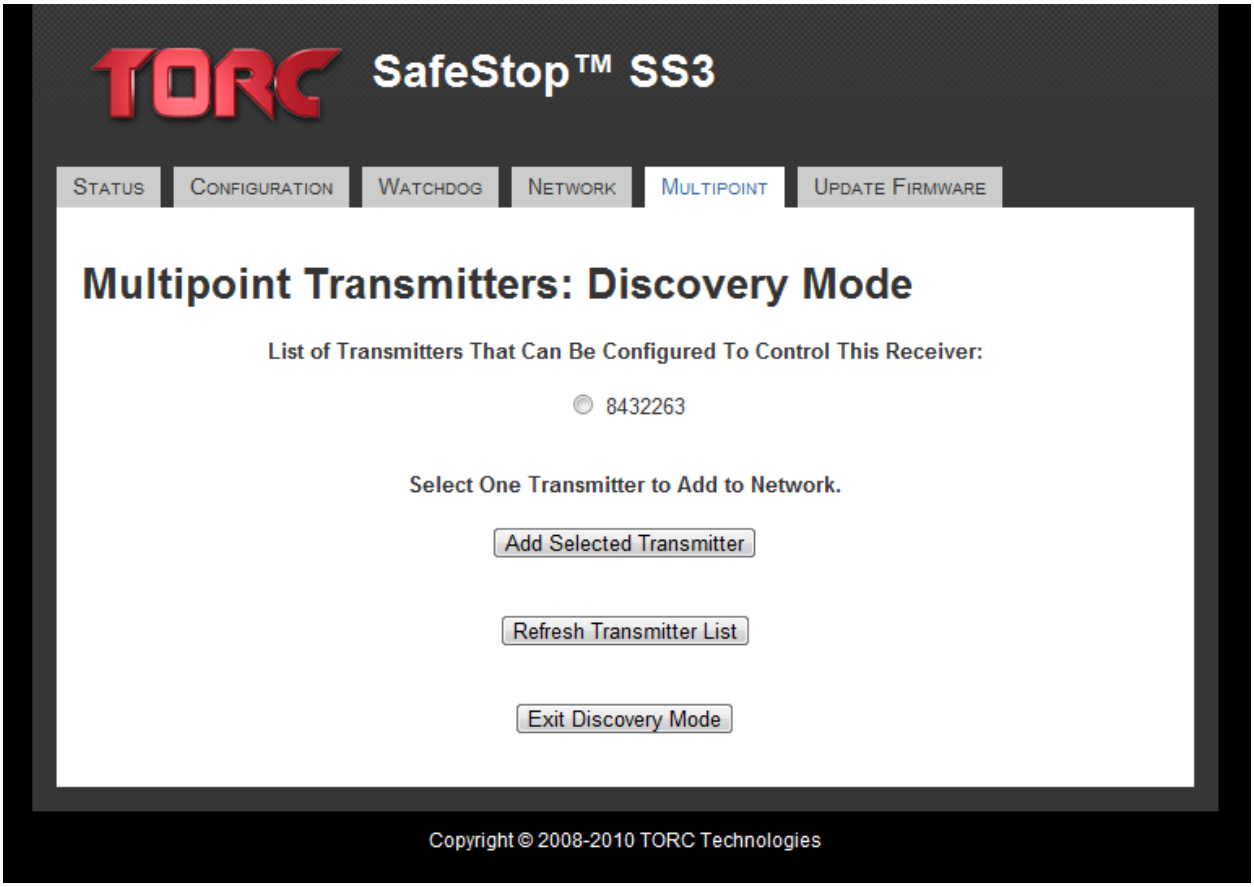


Figure 11-6: Multipoint Discovery Webpage

10.6 Firmware Updates

The SafeStop™ system features the ability to update the firmware through a web interface. To update the firmware follow the steps outlined below.

1. Turn on the power to the SafeStop™ transmitter and receiver and connect the receiver to a computer through one of the Ethernet receptacles
2. Open a web browser and enter the receiver's IP address into the address field of the web browser. The default address is **192.168.0.160**
3. Under the firmware update tab, select the "Browse" button corresponding to the type of firmware update to be performed (Receiver primary processor, Receiver secondary processor, or Transmitter). Locate the appropriate firmware file provided by TORC and click the "Open" button.
4. Select the "Update Receiver" button to load the firmware onto the receiver, "Update Secondary" button to load the firmware onto the secondary processor, or the "Update Transmitter" button to load the firmware onto the transmitter.
5. When updating the receiver firmware, the receiver LEDs may all turn off, and any transmitters powered on will lose their link status. When updating the secondary processor, there will be a brief "stop" state, which will persist if latched. When updating the transmitter firmware, the transmitter LEDs may remain off for a few moments after the transmitter power is cycled the first time following the update.
6. When the receiver firmware has been updated successfully, the webpage will be automatically redirected to the System Configuration page. Upon a successful transmitter firmware update, a webpage will be displayed indicating that the transmitter must be reset to finalize the updating process.
7. Unless otherwise specified, firmware should always be updated on the transmitters first, followed by the receiver secondary processor, followed by the primary receiver firmware.

Warning: Updating firmware in the wrong order could cause the transmitter to become unreachable.

WARNING: Updating firmware to a SafeStop™ transmitter requires that only a single transmitter is powered on and paired with the receiver, and that a wireless link is established with the receiver. The presence of multiple paired transmitters will cause the transmitter firmware update to fail.

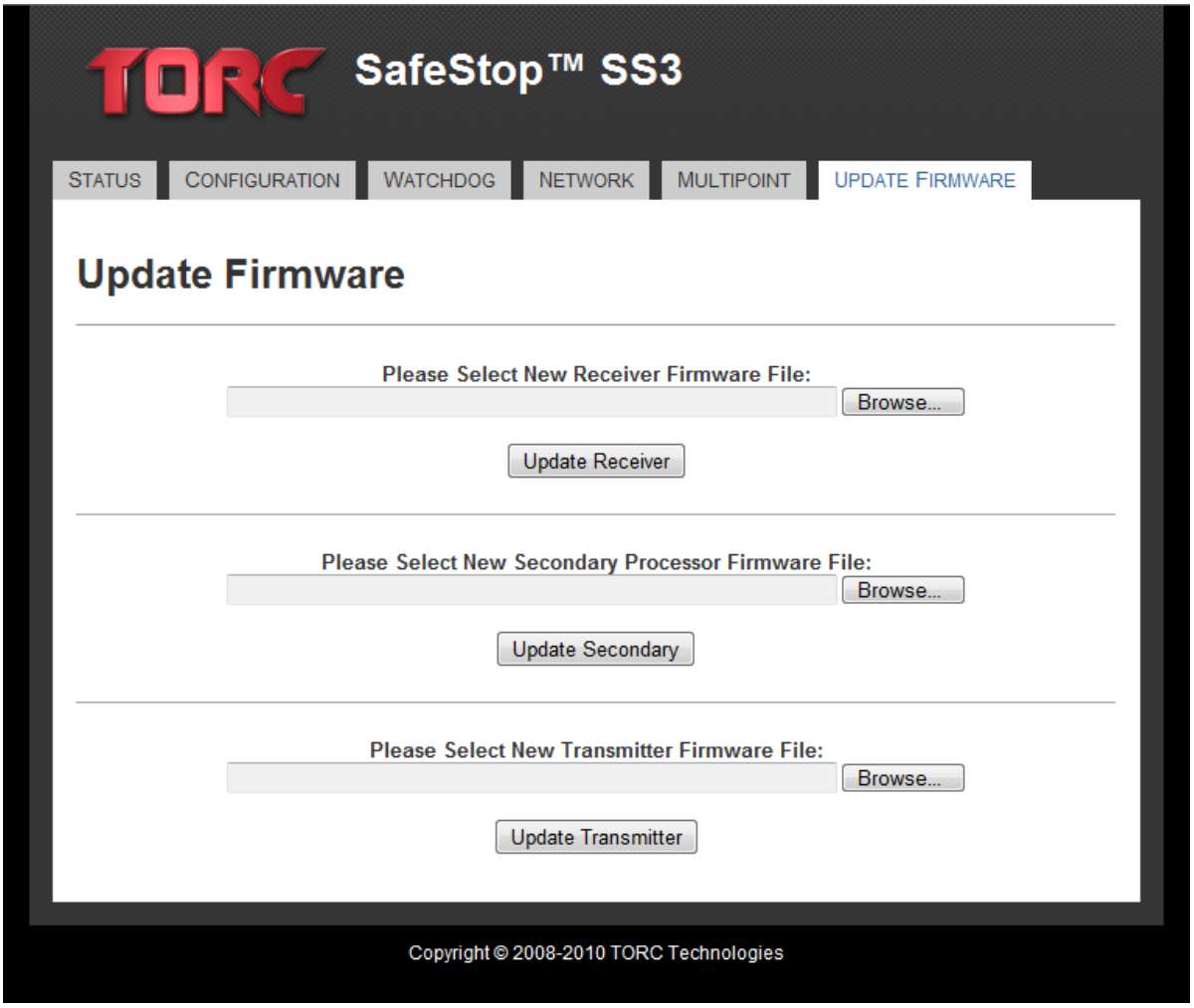


Figure 11-7: Update Firmware Webpage

12 RESTORE NETWORK AND SYSTEM DEFAULTS

If it becomes necessary to restore the default network settings on the SafeStop™ receiver the user should perform the following steps.

1. Power off the receiver
2. Hold down the Bypass button while power to the receiver is switched on
3. The Bypass button should be illuminated blue
4. Continue to hold the bypass button for 10 seconds
5. After 10 seconds the Bypass button illumination will turn off
6. The receiver should now be configured to use the factory default IP network settings and system configuration settings.

13 SYSTEM INTEGRATION

Before your SafeStop™ can be used, you need to perform the following steps: fully charge the transmitter battery, install the antennas, install the receiver cables, and verify proper system operation.

13.1 Charging the Transmitter Battery

Before using the SafeStop™, the transmitter battery should be fully charged. The transmitter can be charged using the included AC adapter. To charge the battery, plug the AC power supply into the Charging Receptacle. When connected to an external power supply, the Charge Status Indicator will be orange while the battery is charging and green when the battery is fully charged. Operating the SafeStop™ system while connected to external power will not drain the battery or reduce the charge time if the power adapter is properly connected.

WARNING: Do not leave the SS03TX transmitter unattended while charging the battery.

WARNING: Only charge the battery using an approved power adapter.

13.2 Installing the Antennas

Before turning the SafeStop™ transmitter or receiver on, the device antennas must be properly connected. Install the antennas by threading them clockwise onto the corresponding RP-TNC antenna connectors.

CAUTION: Do not over tighten antenna connectors.

13.3 Installing the Receiver Cables into the Vehicle System

The installation of the receiver consists of properly wiring the Power cable and the Safety cable. Using the supplied power cable (P/N: SS03PWR), power the receiver using a power source (not included) capable of 8 Watts at 10-40VDC. The power cable's (P/N: SS03PWR) red wire should be connected to the positive terminal, and the black wire should be connected to ground.

CAUTION: Connecting the receiver to a voltage outside the 10 to 40 volt range may cause the system not to function properly.

13.4 Example 5V Logic Level Wiring Schematics

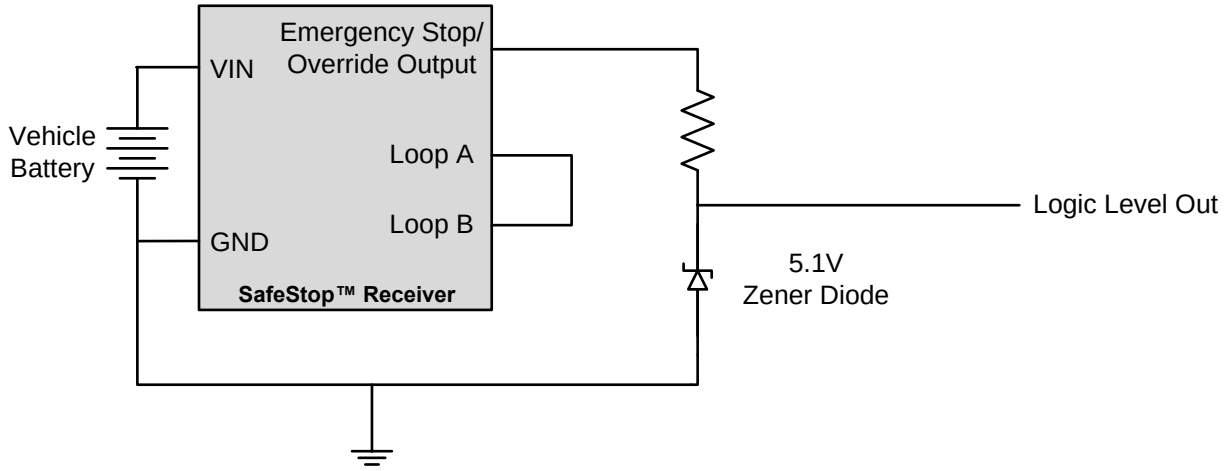


Figure 13-1: Example External 5V Logic Schematic

13.5 Example Vehicle Wiring Schematics

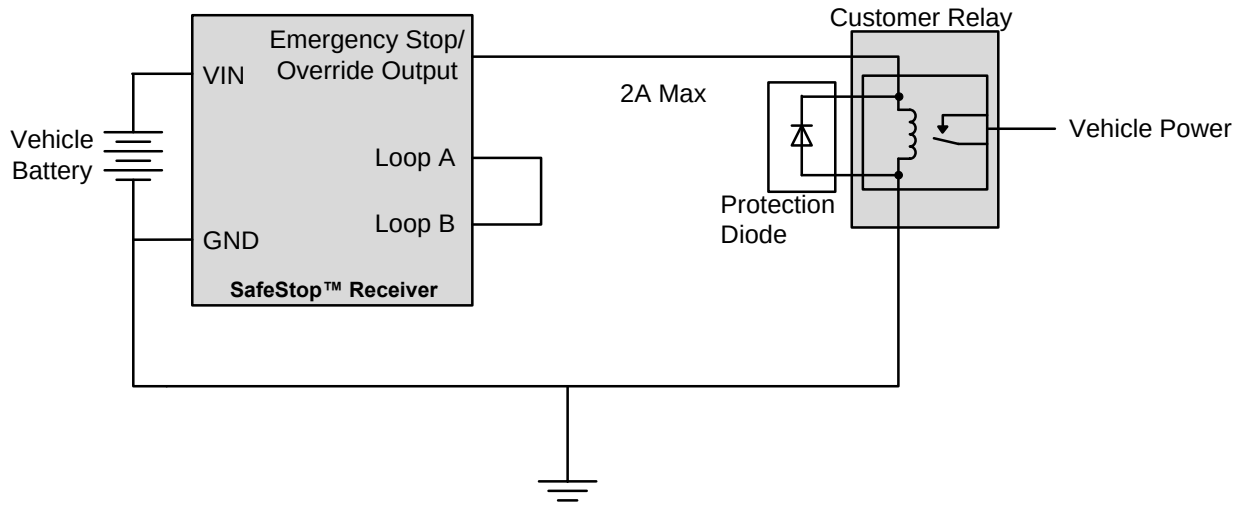


Figure 13-2: Example External Relay Interface

WARNING: When switching inductive loads such as relays, a protection diode must be used to suppress voltage transients.

13.6 Example External Button Wiring Schematics

The button loops for both Emergency Stop and Emergency Override operate in the same manner. All buttons should be connected in series with the Loop A and Loop B pins. Normally closed buttons should be used so that when any one button is pressed (the contacts become disconnected) the output is driven low to ground.

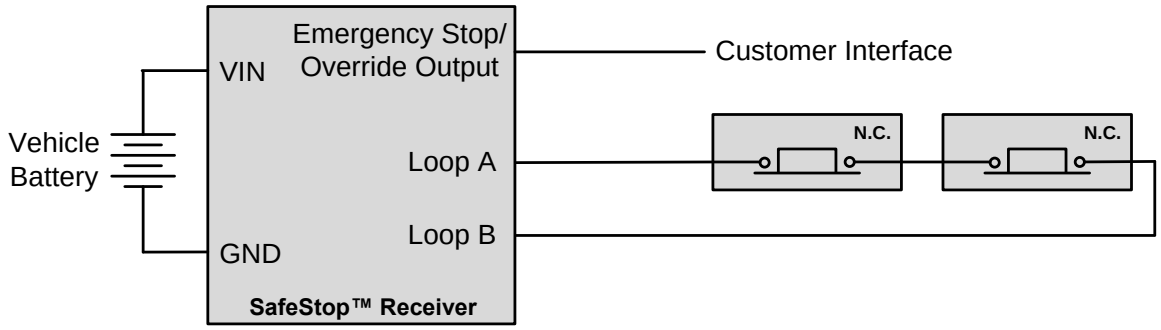


Figure 13-3: External Button Schematic

13.7 Verify Operation of the System

After connecting the power and safety cables to the SafeStop™ receiver, turn the power to the receiver on (the transmitter should not be powered at this time). The transmitter AC adapter uses the same pin out as the receiver power connector and is capable of powering the receiver for the initial bench test. Once power to the receiver is turned on, the status indicator lights should correspond to the table shown below.

Operation Test: Transmitter OFF Receiver ON (receiver status indicators)		
Indicator	**Status**	**Meaning**
Power	Green	Unit power is on
Link	Red	Communications link to transmitter has been lost
Pause	Red	System is paused
Stop	Red	Stop output is connected to GND
Bypass	Off	Normal Operation

To verify the operation of the receiver and transmitter working together, turn the SafeStop™ transmitter power on while the receiver is still powered. Once power to the transmitter is turned on, the status indicators should correspond to the values shown in the table below. The Pause and Stop status indicators should depict the state of the Run/Pause toggle switch and Stop button respectively.

Operation Test: Transmitter ON Receiver ON (transmitter status indicators)		
Indicator	**Status**	**Meaning**
Power	Green	Unit power is on
Link	Green	Communications link established
Pause	Green	Run/Pause toggle switch is in Run position
	Red	Run/Pause toggle switch is in Pause position
Stop	Green	Stop button is released
	Red	Stop button is pressed

Operation Test: Transmitter ON Receiver ON (receiver status indicators)		
Indicator	**Status**	**Meaning**
Power	Green	Unit power is on
Link	Green	Communications link established
Pause	Green	Run/Pause toggle switch is in Run position
	Red	Run/Pause toggle switch is in Pause position
Stop	Green	Stop button is released
	Red	Stop button is pressed
Bypass	Off	Bypass Mode not enabled

Turning off power to the receiver while the transmitter is still powered will result in a lost communications link and the status indicators should correspond to the values in the table

below. Upon a loss of link, the transmitter will also emit a constant tone indicating that the link to the receiver has been lost.

Operation Test: Transmitter ON Receiver OFF (transmitter status indicators)		
Indicator	**Status**	**Meaning**
Power	Green	Unit power is on
Link	Red	Communications link to transmitter has been lost
Pause	Off	Run/Pause status message state unknown
Stop	Off	Stop output line state is unknown

Entering into Bypass Mode on the receiver will override any signals being sent by the transmitter. It is possible for the Emergency Stop Output to be in a stopped state if external buttons are used. In Bypass Mode the status indicators on the receiver will correspond to the following table.

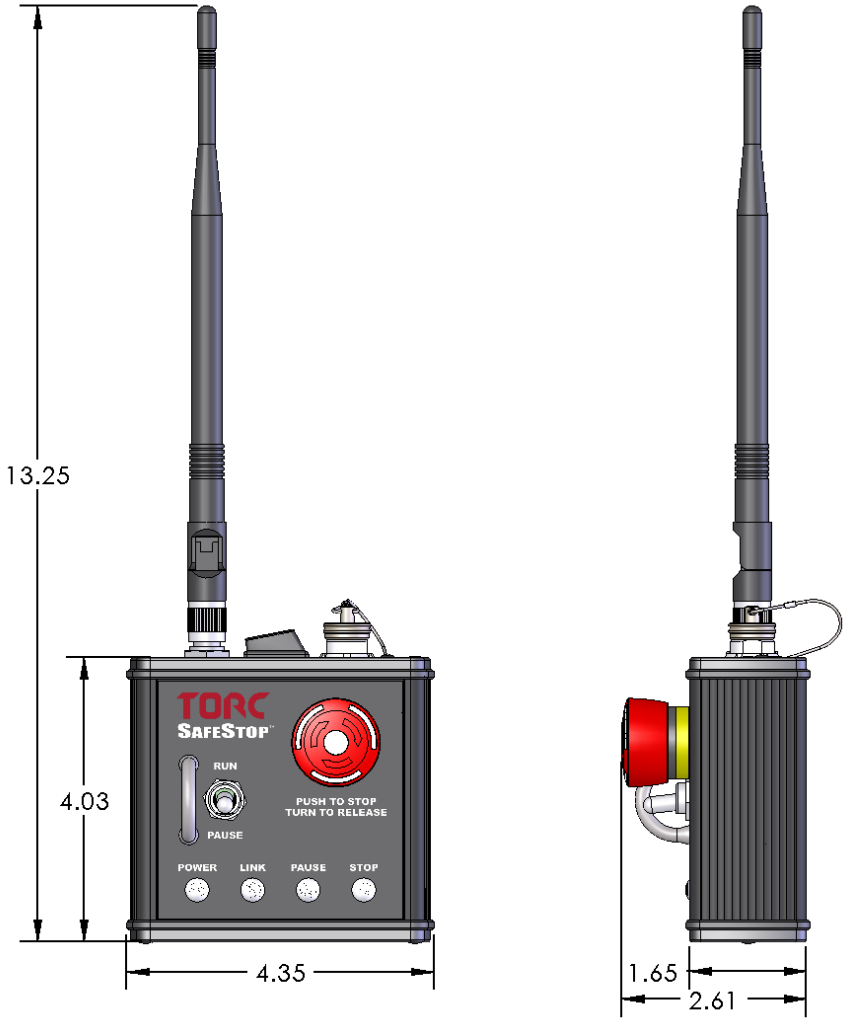
Operation Test: Receiver in Bypass Mode (receiver status indicators)		
Indicator	**Status**	**Meaning**
Power	Green	Unit power is on
Link	Green	Transmitter turned on and in range.
	Red	Communications link disabled
Pause	Green	Status message will indicate Run
Stop	Green	Stop Loop connected, output line tied to VIN
	Red	Stop Loop broken, output line tied to GND
Bypass	Blue	Bypass Mode enabled

WARNING: It is not possible to Stop or Pause a vehicle from the transmitter when the receiver is placed in Bypass mode.

NOTE: It is possible for external stop buttons to put the Emergency Stop Output into a stopped state while the receiver is placed into bypass mode.

14 PHYSICAL DIMENSIONS

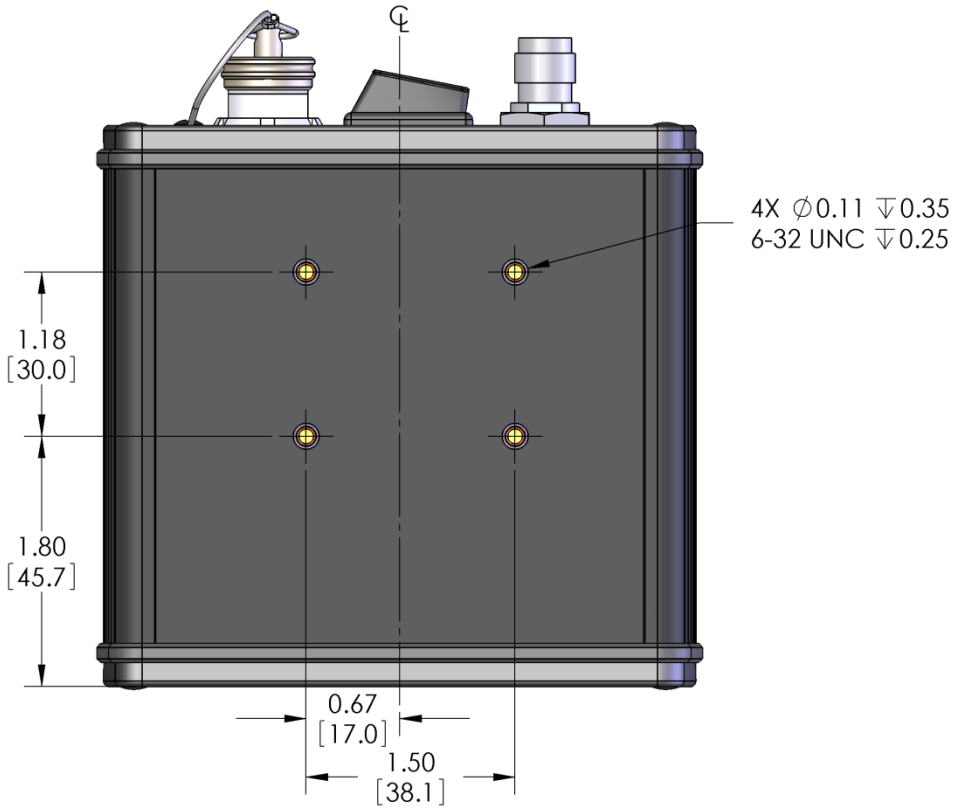
14.1 SafeStop™ Transmitter Dimensions



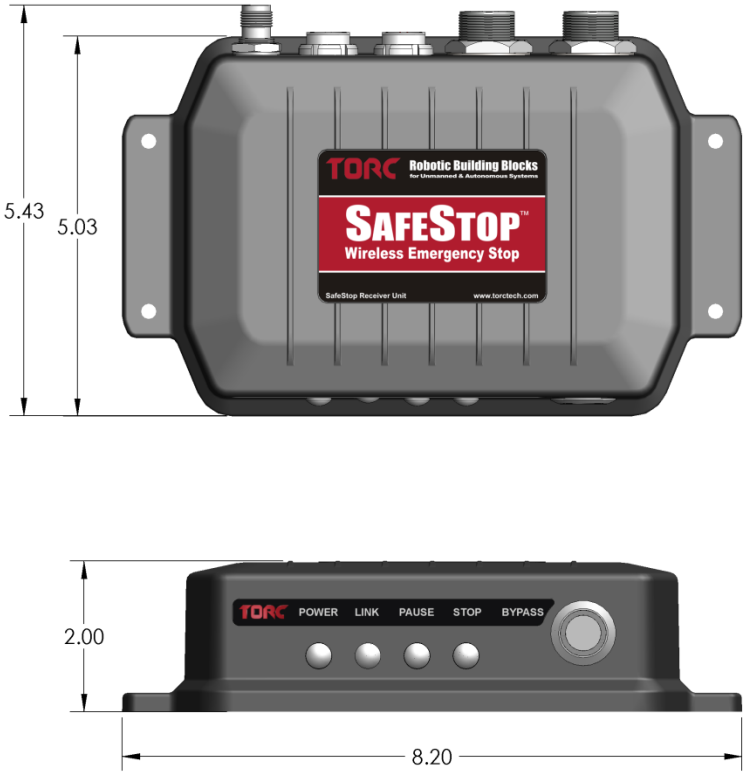
All units in inches 900Mhz Antenna Shown

14.2 Transmitter Mount Dimensions

The SafeStop™ transmitter features a standard AMPS/RAM mount hole pattern on the rear of the unit. Several mounting options are available, contact TORC for details.

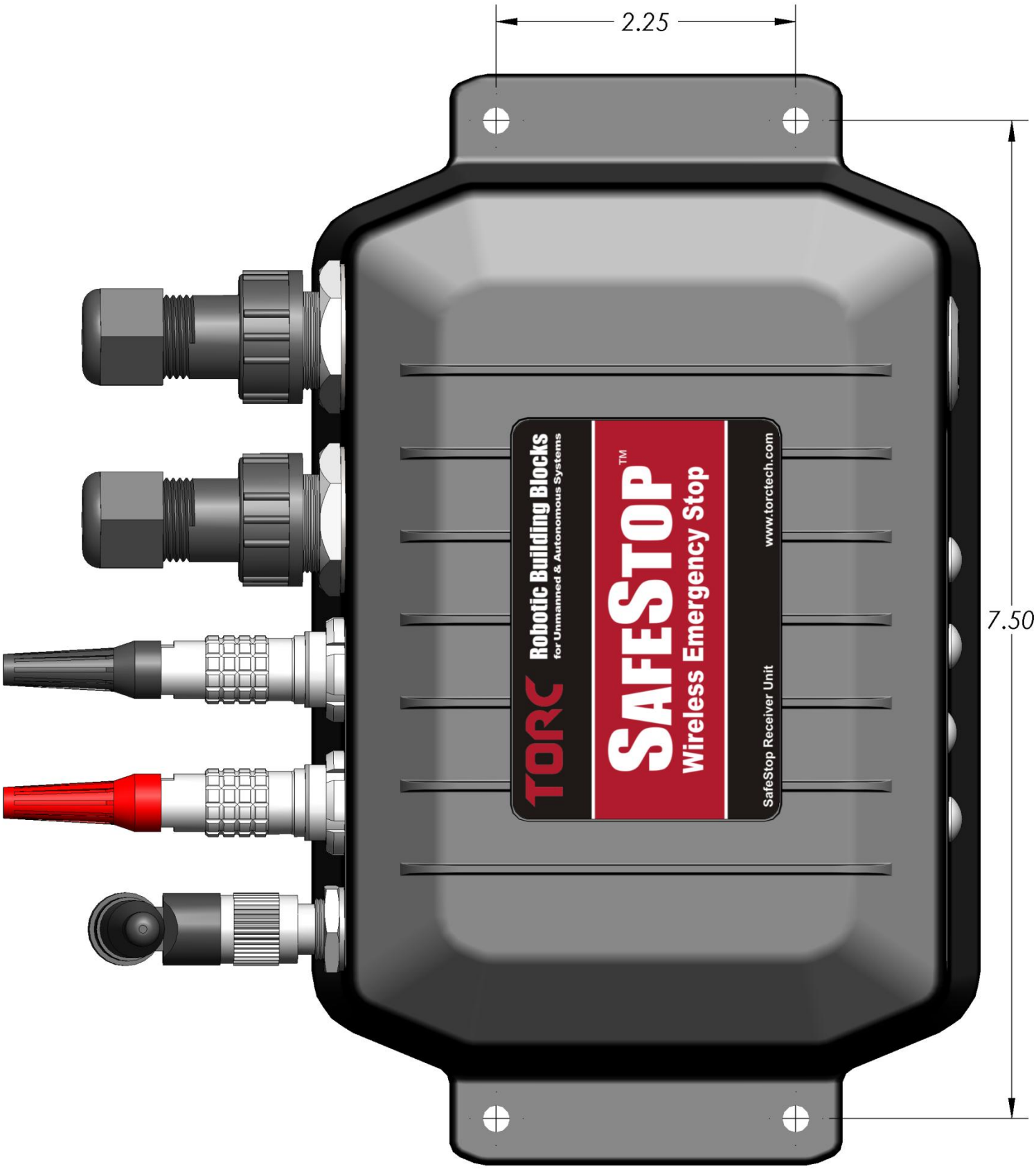


14.3 SafeStop™ Receiver Dimensions



All dimensions in inches

14.4 SafeStop™ Receiver Mounting Template


2.25
7.50
TORC
Robotic Building Blocks
for Unmanned & Autonomous Systems
SAFESTOP™
Wireless Emergency Stop
www.torctech.com
SafeStop Receiver Unit

15 FCC COMPLIANCE

This equipment has been approved for mobile applications where the equipment should be used at distances greater than 20cm from the human body (with the exception of hands, wrists, feet, and ankles). Operation at distances less than 20 cm is strictly prohibited.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

FCC ID: KNY-42182112519

16 LIMITED WARRANTY

TORC Technologies, LLC (herein referred to as TORC) guarantees that the product(s) you have purchased from TORC are free from defects in materials or workmanship for a period of one year from the original date of purchase. Within this period TORC will, at its sole discretion, repair or replace any components which fail under normal use. This warranty does not cover failures due to abuse, misuse, accident, or unauthorized alterations or repairs.

There are no other warranties, expressed or implied, which extend beyond the description contained herein including the implied warranty of merchantability and fitness for a particular purpose. TORC expressly excludes all other warranties

TORC's liability is limited to the cost of repair or replacement of the product. Such remedy shall be the sole and exclusive remedy for any breach of warranty.

TORC shall not be liable for:

1. Damage to other property caused by any defects in the product, damages based upon inconvenience, loss of use of the product, loss of time, loss of profits, loss of business opportunity, loss of goodwill, interference with business relationships, or other commercial loss, even if advised of the possibility of such damages.
2. Any indirect or other damages, whether incidental, consequential, or otherwise.
3. Any claim against the customer by any other party.

The SafeStop™ firmware incorporates portions of the lwIP TCP/IP networking stack, originally developed by Adam Dunkels at the Swedish Institute of Computer Science. The source code and full text of the associated license agreement may be downloaded from http://savannah.nongnu.org/projects/lwip.